Hydraulic and Hydrologic Considerations in Planning Course

FLOOD RISK MANAGEMENT

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Objectives

- To review for students:
  - An overview of the analyses typically used in Flood Risk Management (FRM) studies.
  - The type of data needs for H&H analyses.
  - Various types of FRM alternatives (structural and non-structural measures) and the expected impacts of the alternative types.
  - H&H outputs to the study team.

References

- EM 1110-2-1419, Hydrologic Engineering Requirements for Flood Damage Reduction Studies, 31 Jan 95
- EM 1110-2-1417, Flood Runoff Analysis, 31 Aug 94

Flood Risk Management

H&H Steps in a Flood Risk Management Study

- Preliminary Investigations
- Development of Basin Model
- Hydraulic Studies
- Calibrate Models to Existing Conditions
- Frequency Analysis for Existing Land-Use Conditions
- Future Without-Project Conditions
- Alternative Evaluations
- Hydraulic Design
- H&H Outputs and Reporting

Preliminary Investigations

- Initial Preparation
- Obtain Study Area Maps (define watershed boundaries)
- Determine mapping, cross-section data, and high water mark requirements
- Field Reconnaissance
- Prepare Survey Request for mapping requirements and/or cross-sections and high water marks

Initial Preparation

- Scope Study Objectives and Purpose
- Study Team determine:
  - H&H and Study Team requirements
  - Study Constraints ($, Rights-of-way, etc)
- Review Available Documents
  - Previous USACE work (incl Recon studies)
  - USGS or other Federal Agency Reports
  - Local Studies and Other related materials
- Collect Existing Data:
  - Historic & Design Discharges
  - Discharge-Frequency Relationships
  - High Water Marks
  - Cross-Section, Bridge, and Culvert Data
- Scope Major H&H Engineering Activities

Surveying Requirements

- Obtain study area maps.
- Determine required survey data needs
- Field Reconnaissance
  - Interview sponsor, residents, local agencies
  - Finalize cross-section/mapping needs
  - Estimate initial roughness values for channels and overbanks
  - Photograph channels and floodplain, bridges, culverts, weirs, etc.
- Prepare Survey Request for mapping requirements, cross-section data, and high water mark data

Development of Basin H&H Models

- Calibration of runoff parameters
- Delineation of subareas
- Subarea rainfall-runoff analysis of historic events
- Channel routing characteristics
- Reservoir routing (if present)
- Generate hydrographs

Hydraulic Studies

- Prepare water surface data
- Proportion discharges
- Check Elevations
- Obtain Rating curves

Calibration of Models to Historic Events

- Check Hydrologic Model
- Calibrate models to high water marks
- Adopt H&H model parameters for hypothetical frequency analysis

Frequency Analysis for Existing Land-Use Conditions

- Develop Frequency Curves for each stream gage
- Develop Frequency Storms
- Develop Frequency hydrographs using calibrated model
- Calibrate model of each frequency event to known frequency curves
- Develop analytical frequency curves for ungaged watersheds, if necessary
- Determine frequency water surface elevations and profiles from rating curves

Future Without-Project Conditions

- From future land-use planning data, identify extent of future urbanization
- Select future years in which to determine project hydrology
- Adjust model hydrology parameters for all affected subareas
- Model future conditions & determine revised discharge-frequency relationships in watershed

Alternative Evaluations

- Modify existing & future without-project models to simulate individual alternatives or components
- Model alternative features
- Evaluate effects of components on sediment regime
- Consider non-structural components
- Perform alternative evaluation and selection

Hydraulic Design

- **Perform hydraulic design commensurate with the level of detail of the study**
  - **Reservoirs**
  - **Levees**
  - **Channel Improvements**
  - **Diversions**
  - **Pumping**
  - **Nonstructural Measures**

H&H Outputs

- **Evaluating alternatives** – supporting benefit and cost development.
- **Benefits:** Providing input to the economic models to determine existing damages, Future without Project damages, and damages prevented (Stage/Flow Frequency data).
- **Cost Analysis:** Hydraulic design of alternatives features for design/cost analysis

H&H Outputs

- **Supporting Benefit Analysis:**
  - **Stage-Discharge Frequency data for Existing, Future Without-Project, and Alternative(s) Conditions**
- **Supporting Cost Analysis:**
  - **Hydraulic design of alternatives features for design/cost analysis**
  - **Alignment or Right-of-Way requirements**
- **Environmental Impacts and Features**

Don’t Forget Risk & Uncertainty Analysis

Risk & Uncertainty Analysis Outputs for Flood Risk Management Studies

- From ER 1105-2-100, FRM studies will provide:
  - Estimate of NED (Net Economic Development) Benefits & Benefit/Cost Ratio for each alternative
    - Include probability that Net Benefits are positive
    - Probability that B/C Ratio is at or above 1.0
  - Expected Flood Risk Management Performance to include:
    - Annual Exceedance Probability with associated estimates of uncertainty
    - Equivalent long-term risk of exceedance over 10-, 30-, and 50-years
    - Ability to contain specific historic floods
  - Residual Risk - Expected annual probability of each alternative being exceeded.

Developing FRM Alternatives

Developing FRM Alternatives

- **Team Effort**
  - Planning, Engineering, Environmental, Economics, Stakeholders, Project Mgmt, etc.
- **Define problem locations**
  - Causes of Flooding
  - Economic Damage Locations
  - Environmental Areas of Concern
- **Level of Detail**
  - Reconnaissance, Feasibility, CAP, etc.

Developing FRM Alternatives

- **Alternative Types**
  - **Structural Measures – Physical modifications designed to reduce the frequency of damaging levels of flood inundation *(Get water away from people).***
  - **Non-Structural Measures – Reduces flood damages without significantly altering the nature or extent of flooding *(Get people away from water).***

Structural Alternatives

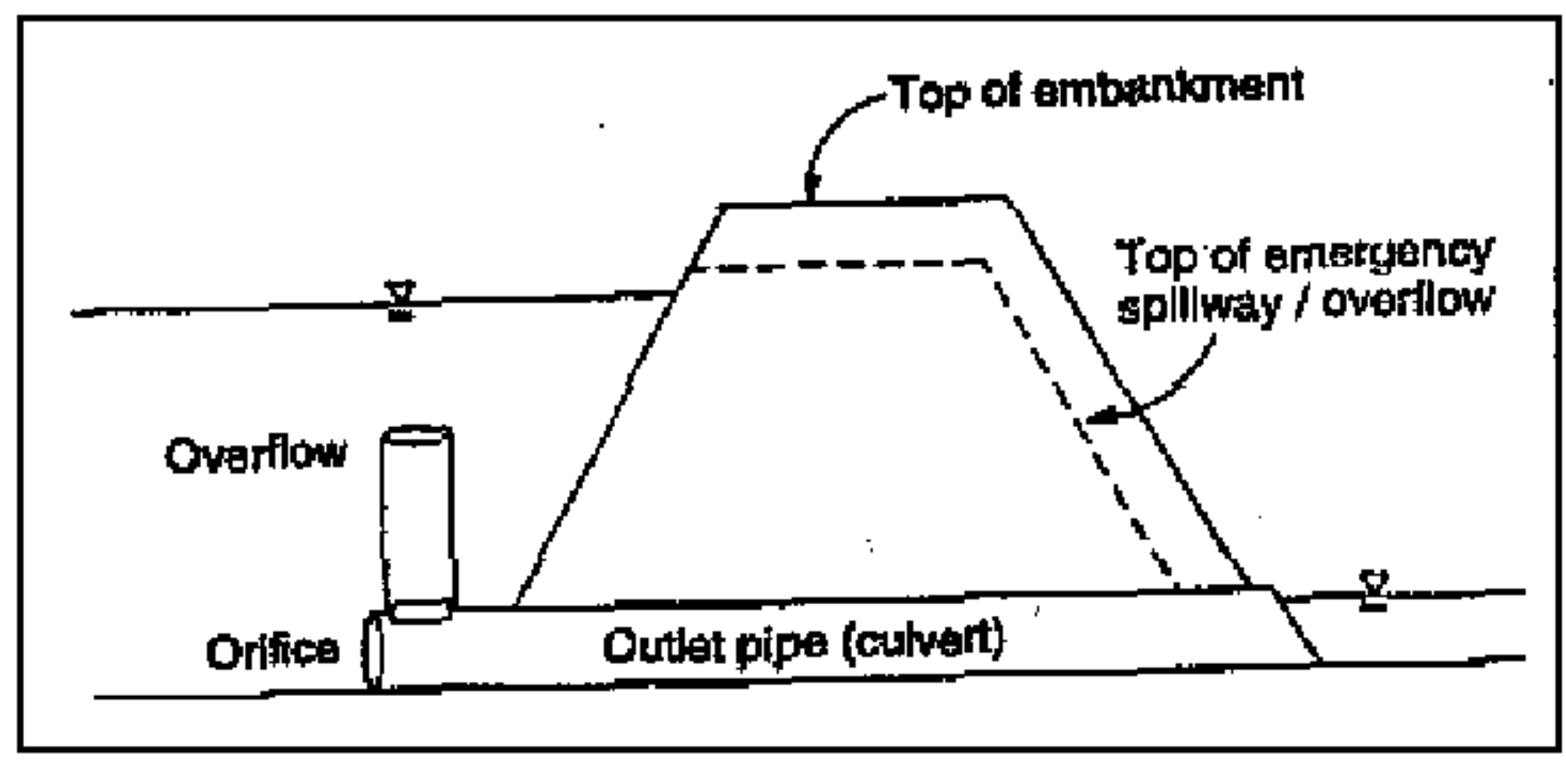
- Reservoirs
- Channels Improvements (including natural stream design)
- Levees and Floodwalls
- Diversions
- Pumps

Non-Structural Measures

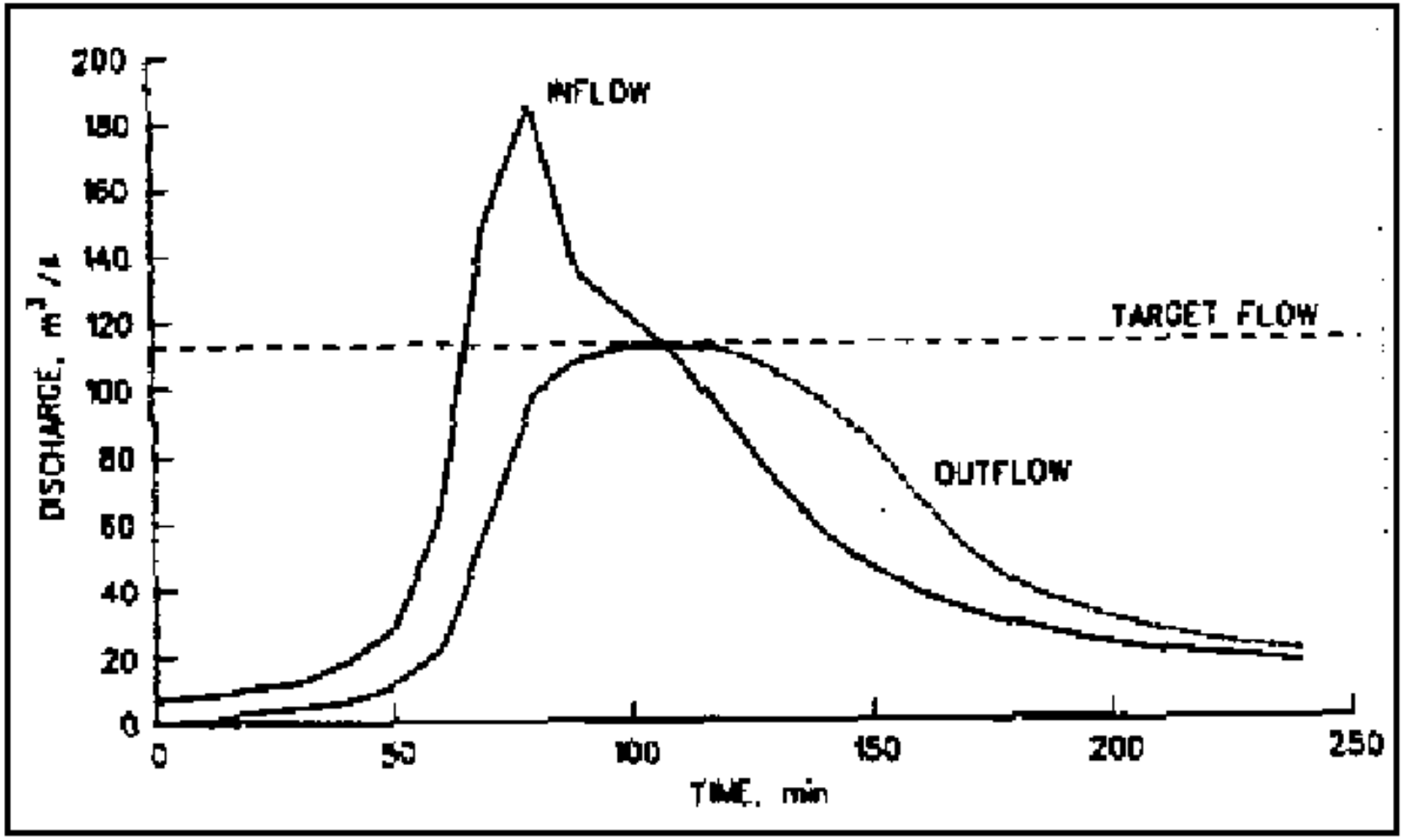
- Flood Proofing
- House Raising
- Relocation
- Flood Warning & Evacuation
- Floodplain Regulation

Dams and Reservoirs

Detention Ponds



Reservoir Hydrograph Impacts



Reservoir Impacts to Discharge-Frequency Curve

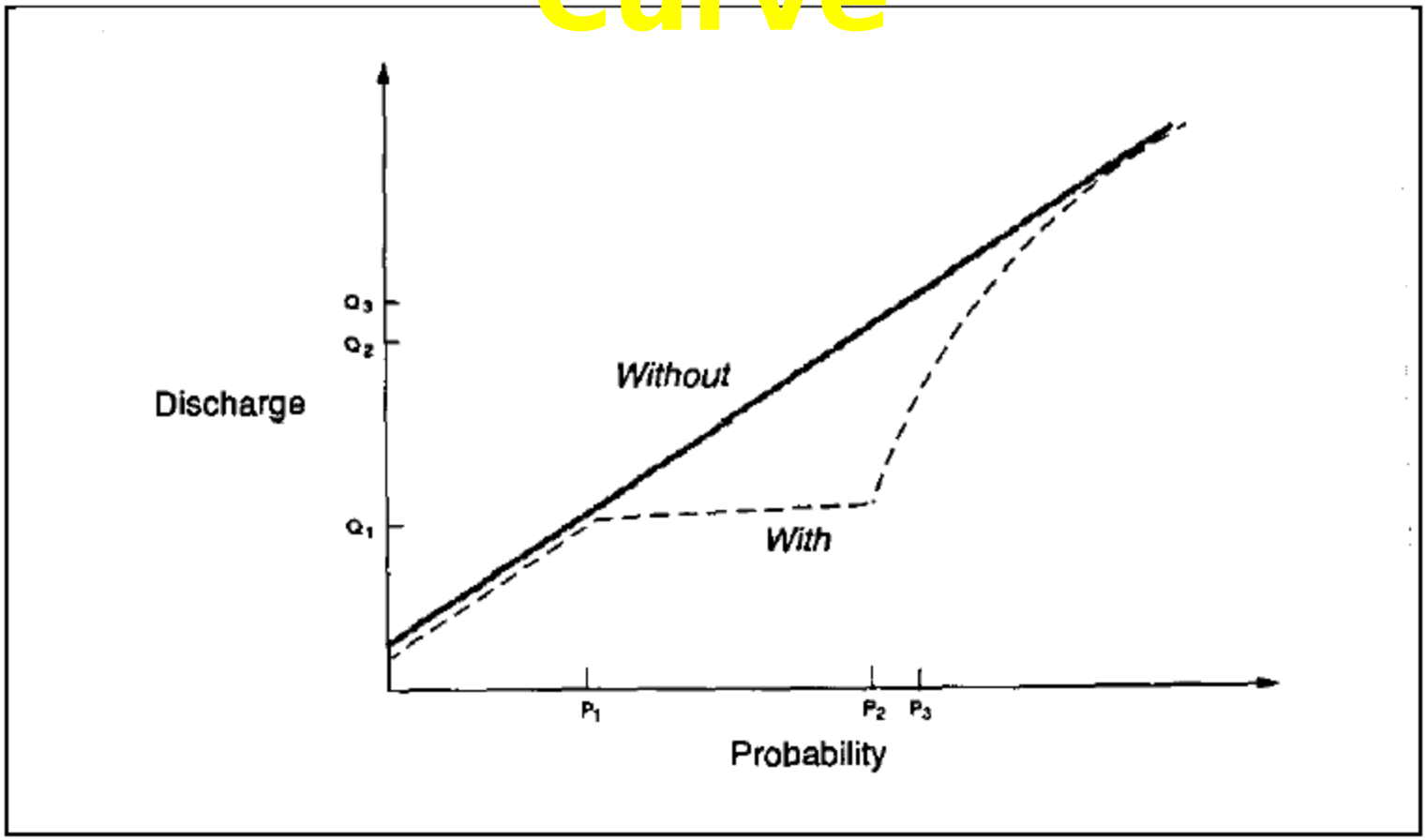
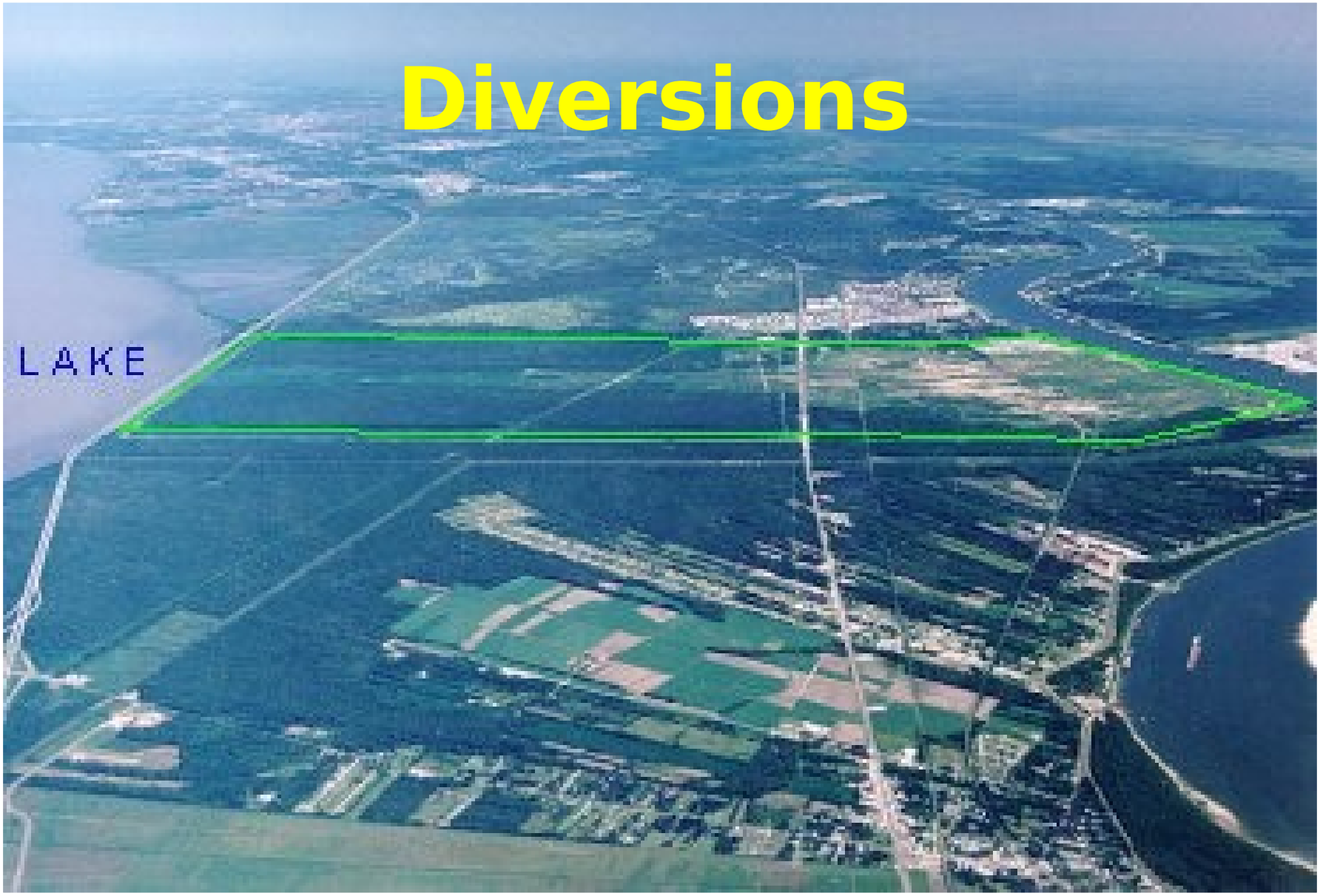


Figure 4-4. Discharge-frequency function modifications due to reservoir

Reservoirs & Dams

- **Performance Considerations**
  - Capacity, Configuration, and Location
  - Operation Rules
  - Other Considerations
- **Dry vs Wet Reservoirs**
- **Dam Safety Evaluation**
  - Minimize Hazard when Capacity is Exceeded
  - Failure Evaluation
- **Environmental Impacts**

Diversions



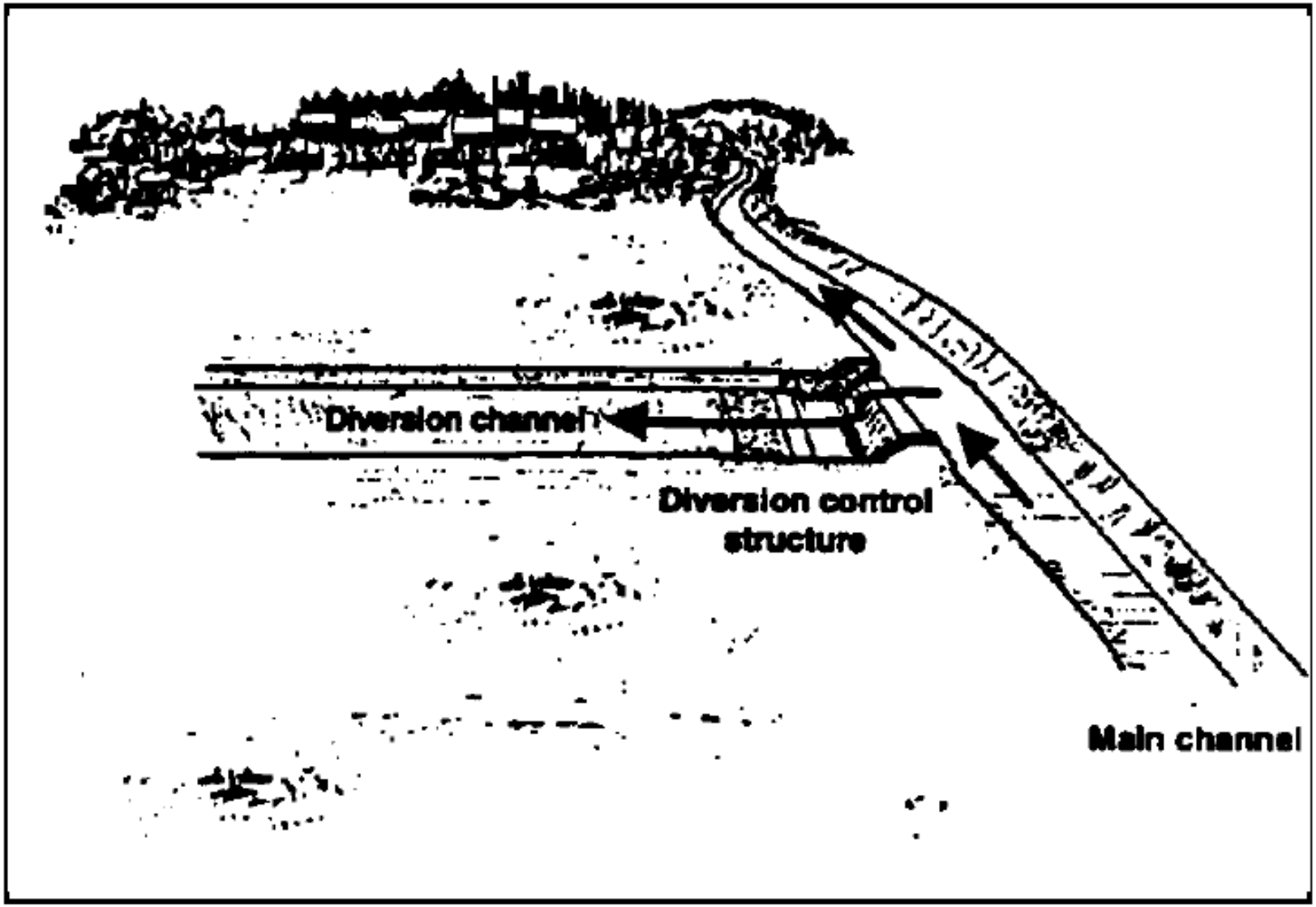


Figure 5-1. Major components of diversion

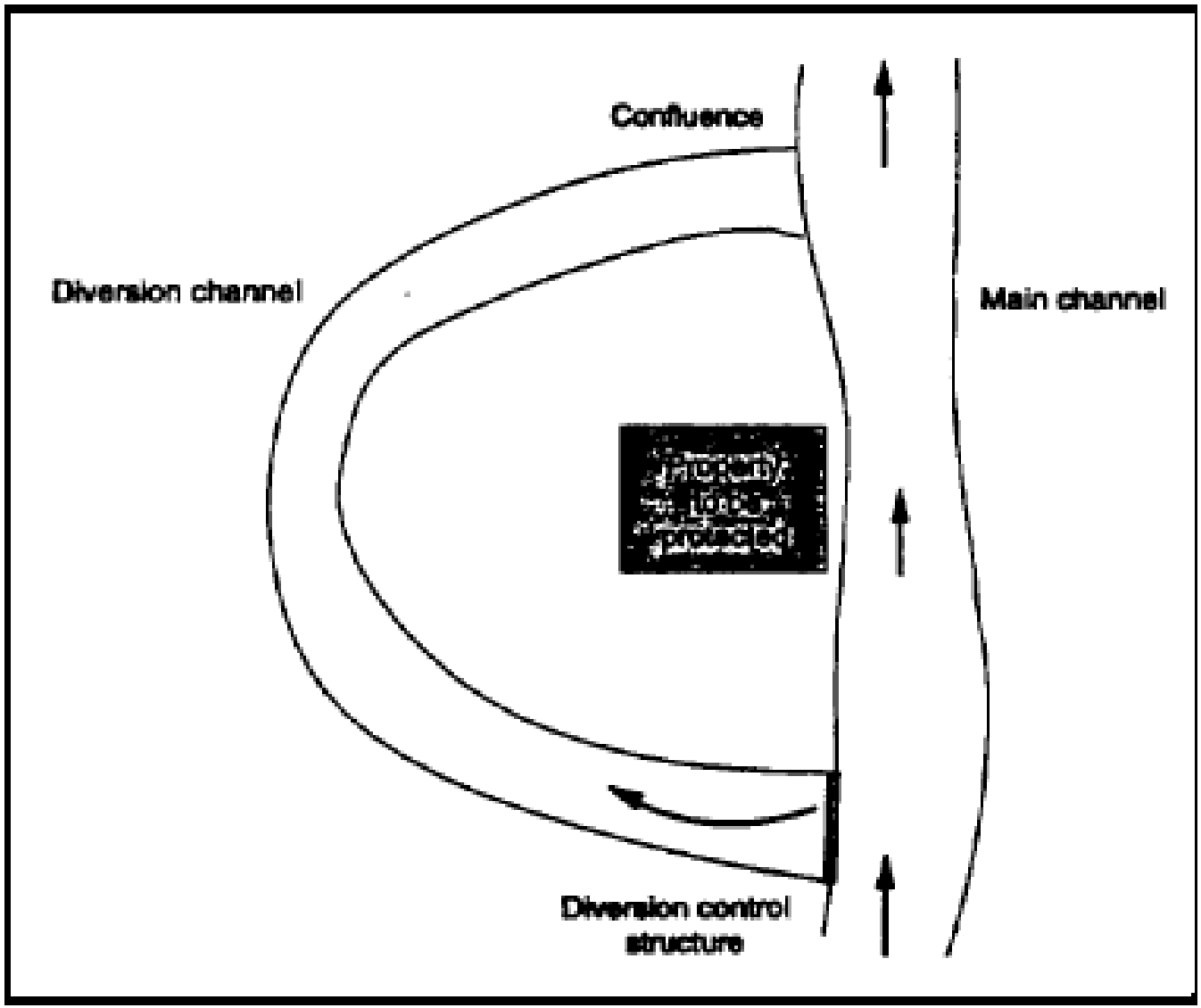


Figure 5-2. Plan view of diversion with downstream confluence

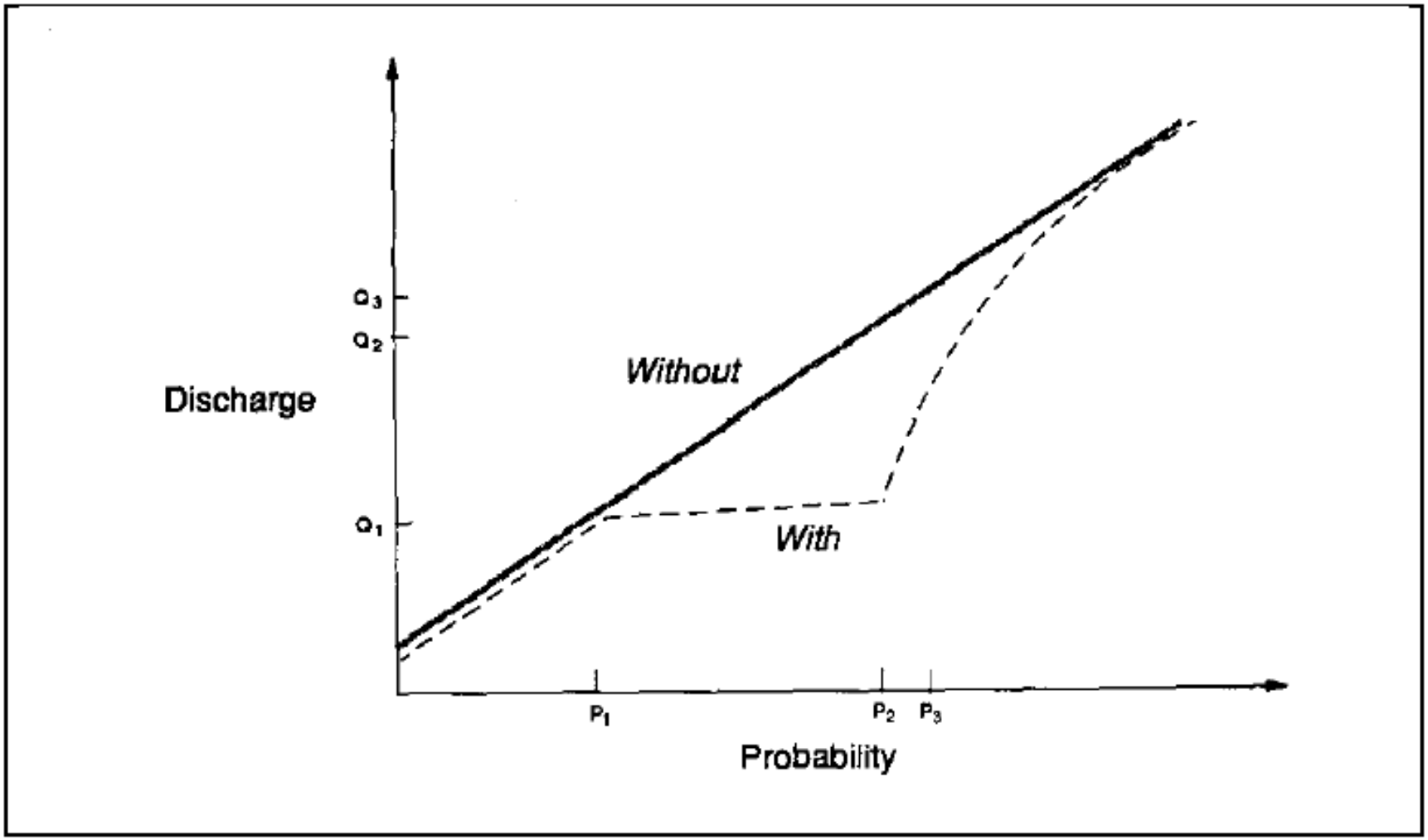


Figure 5-3. Discharge-frequency function modifications due to diversion

Channel Modifications

Channel Modifications

Channel Modifications

- **Types**
  - **Clearing & Snagging**
  - **Enlargement**
  - **Channel Lining (Concrete, Rock, etc.)**
  - **Realignment**

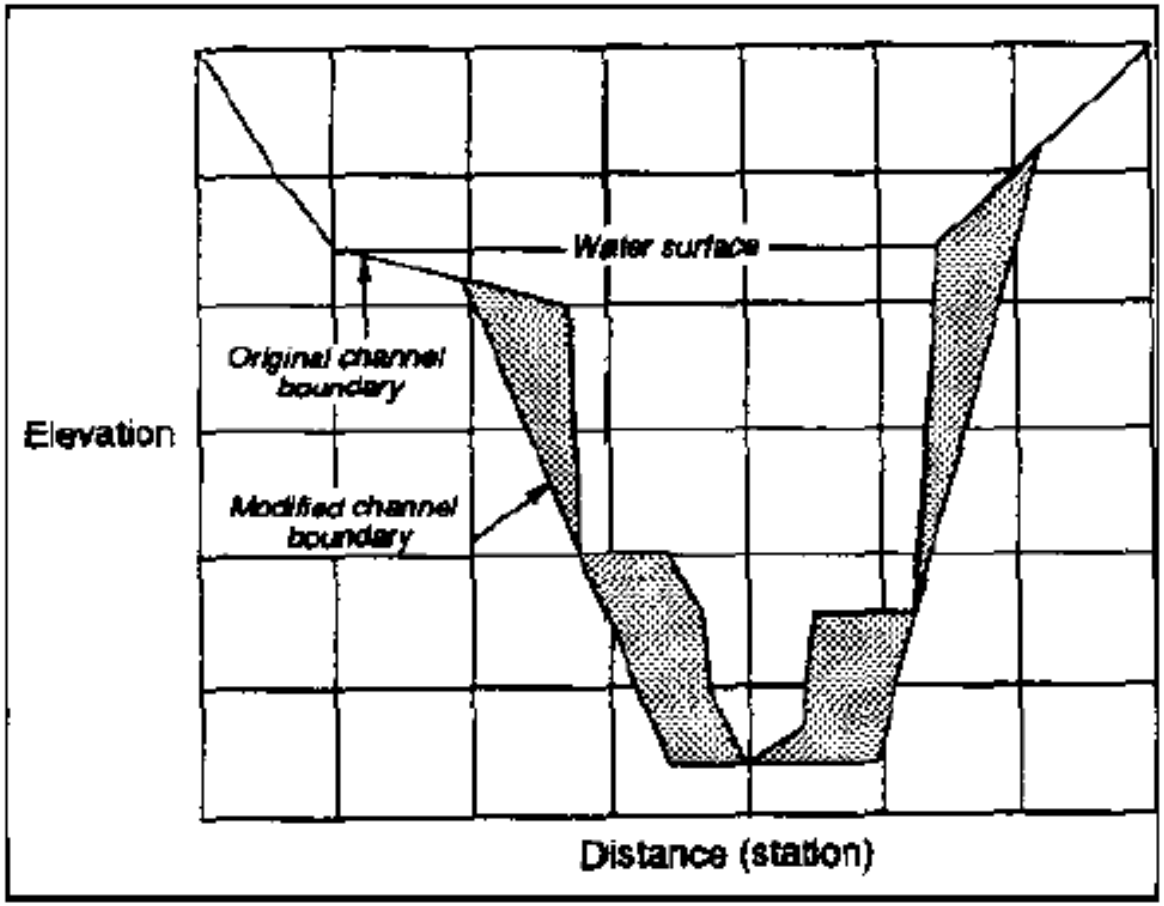


Figure 6-1. Illustration of channel geometry modification

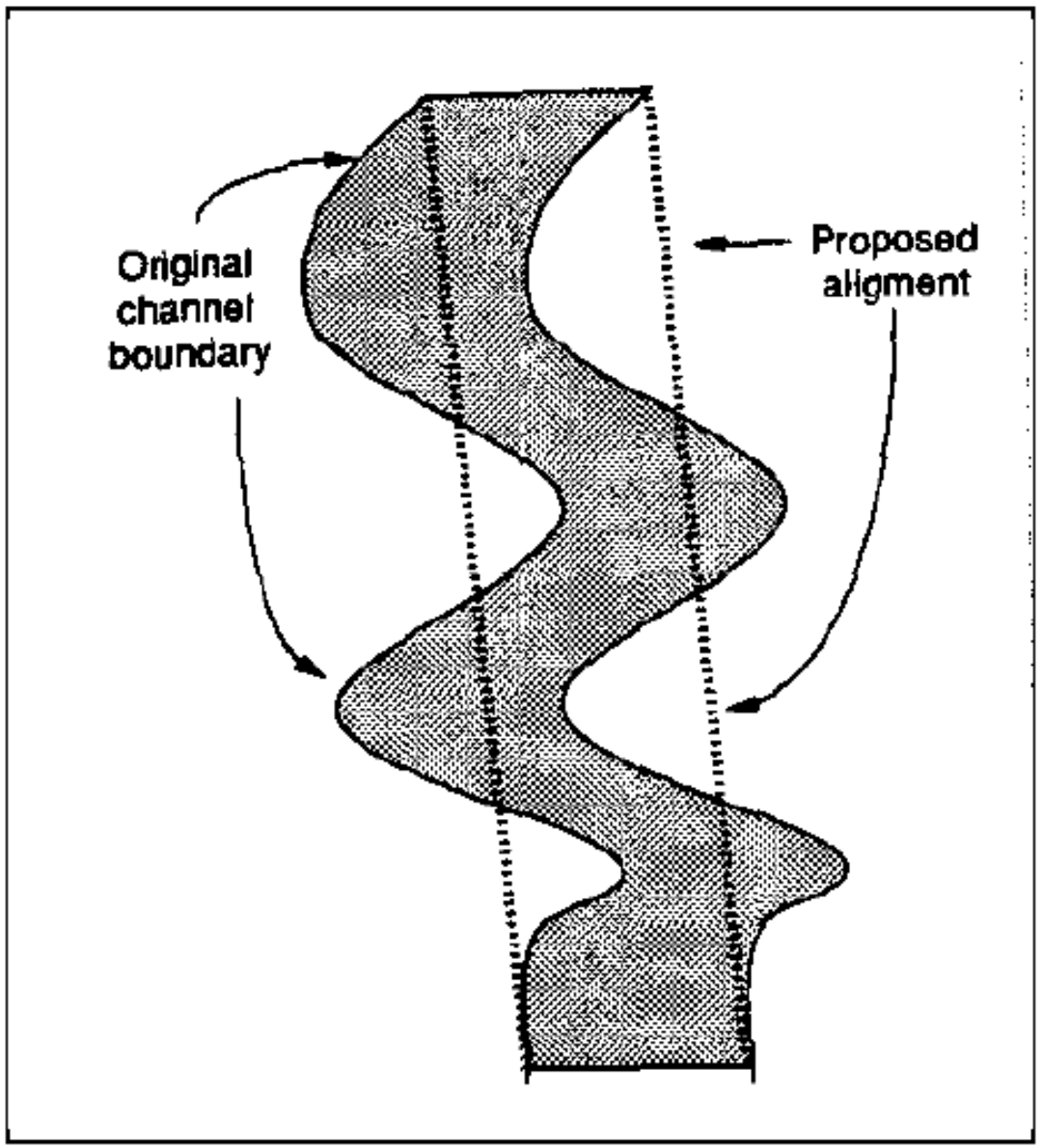


Figure 6-2. Channel re-alignment for damage reduction

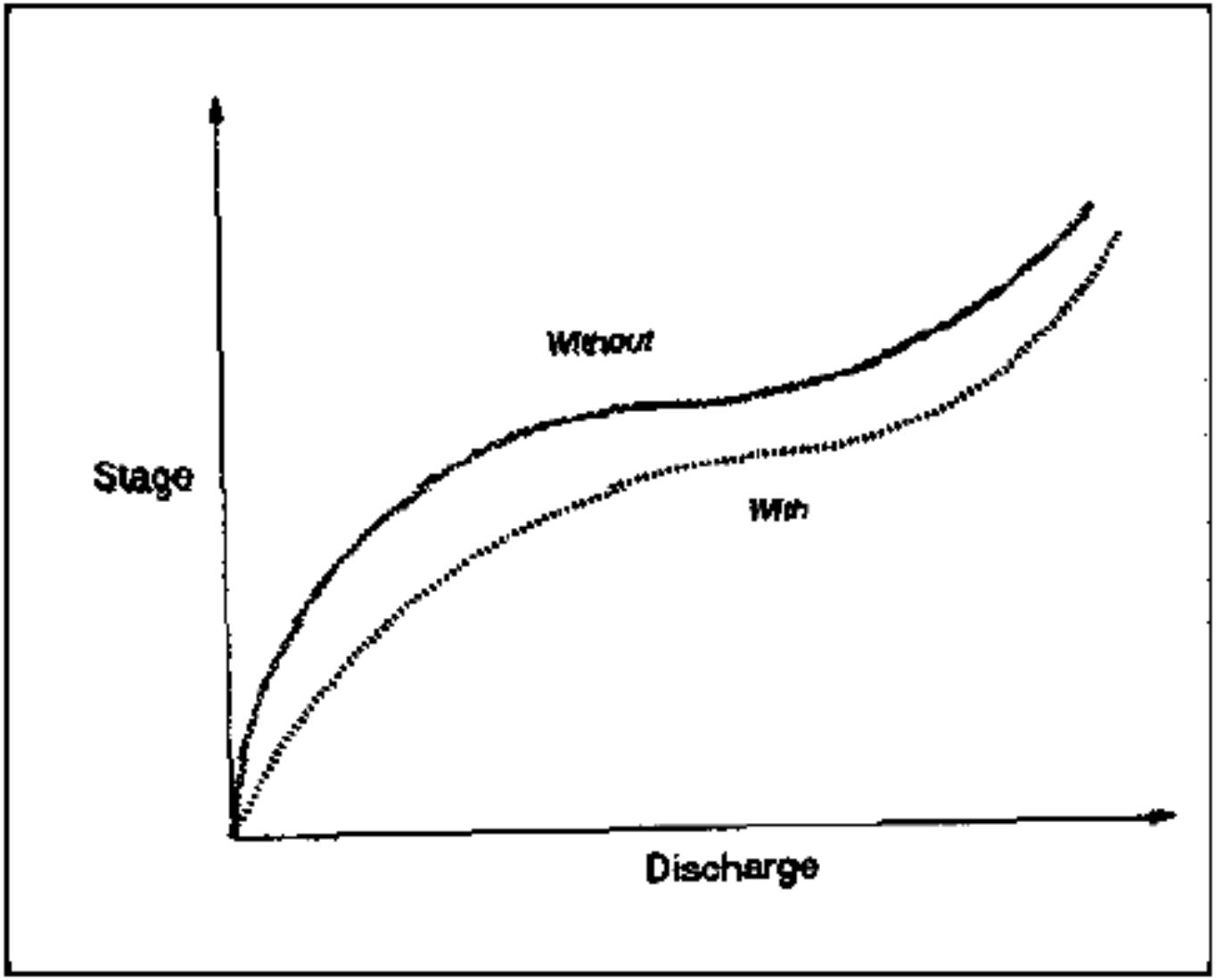


Figure 6-3. Stage-discharge function modifications due to channel improvement

Levees and Floodwall

Monroe, LA Folding Floodwall

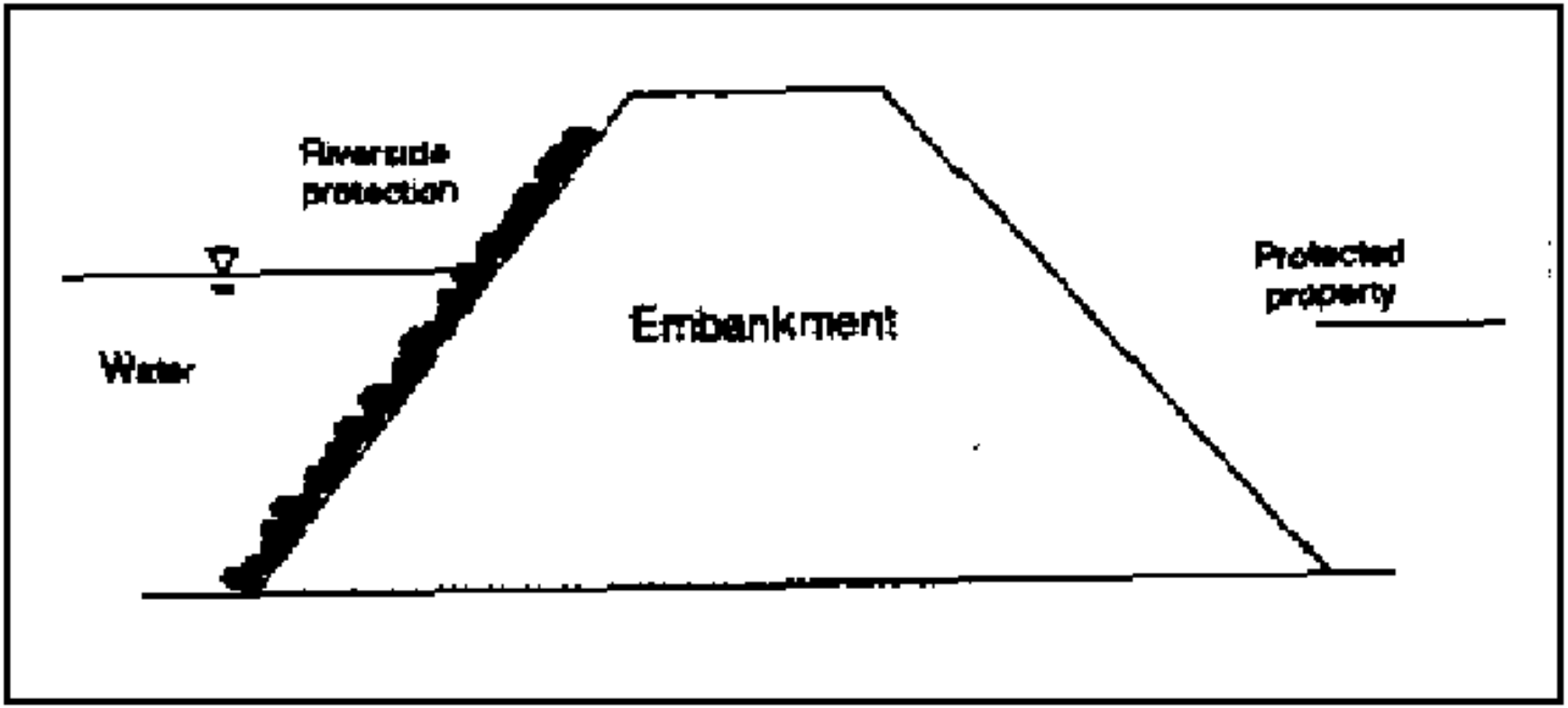


Figure 7-1. Cross section of simple levee

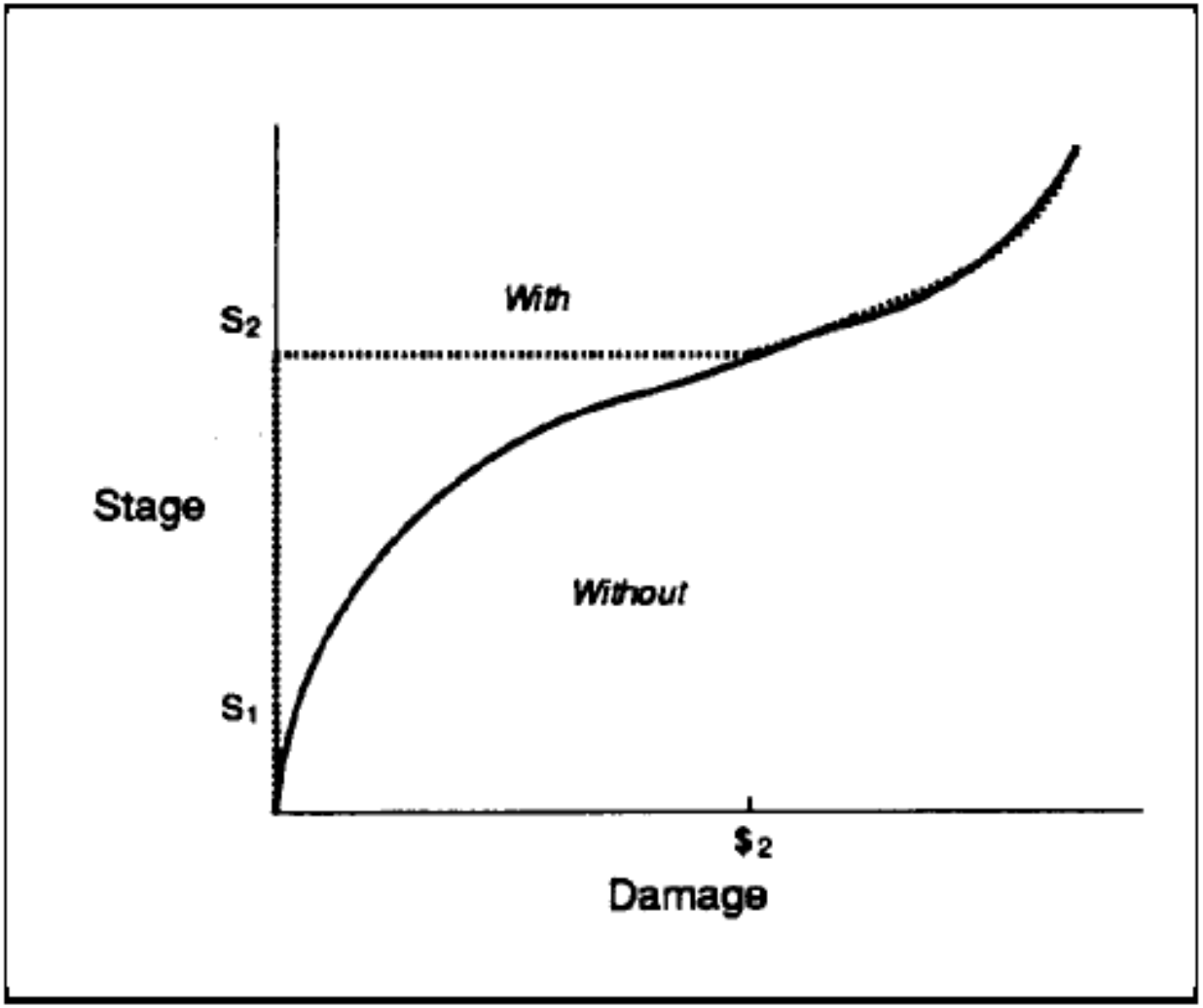


Figure 7-3. Stage-damage function modification due to levee/floodwall

Interior Drainage

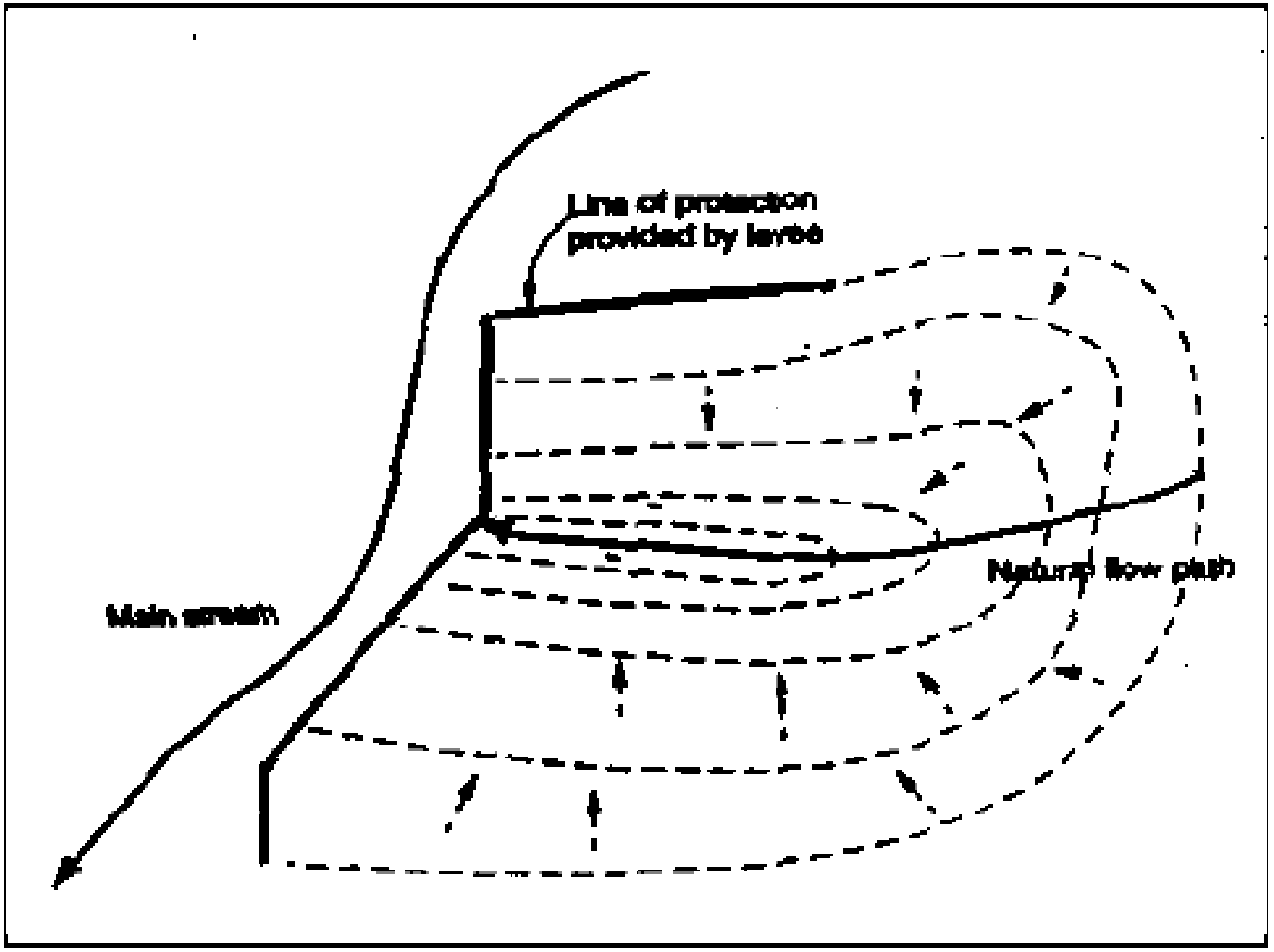


Figure 7-4. Plan view of levee with interior area

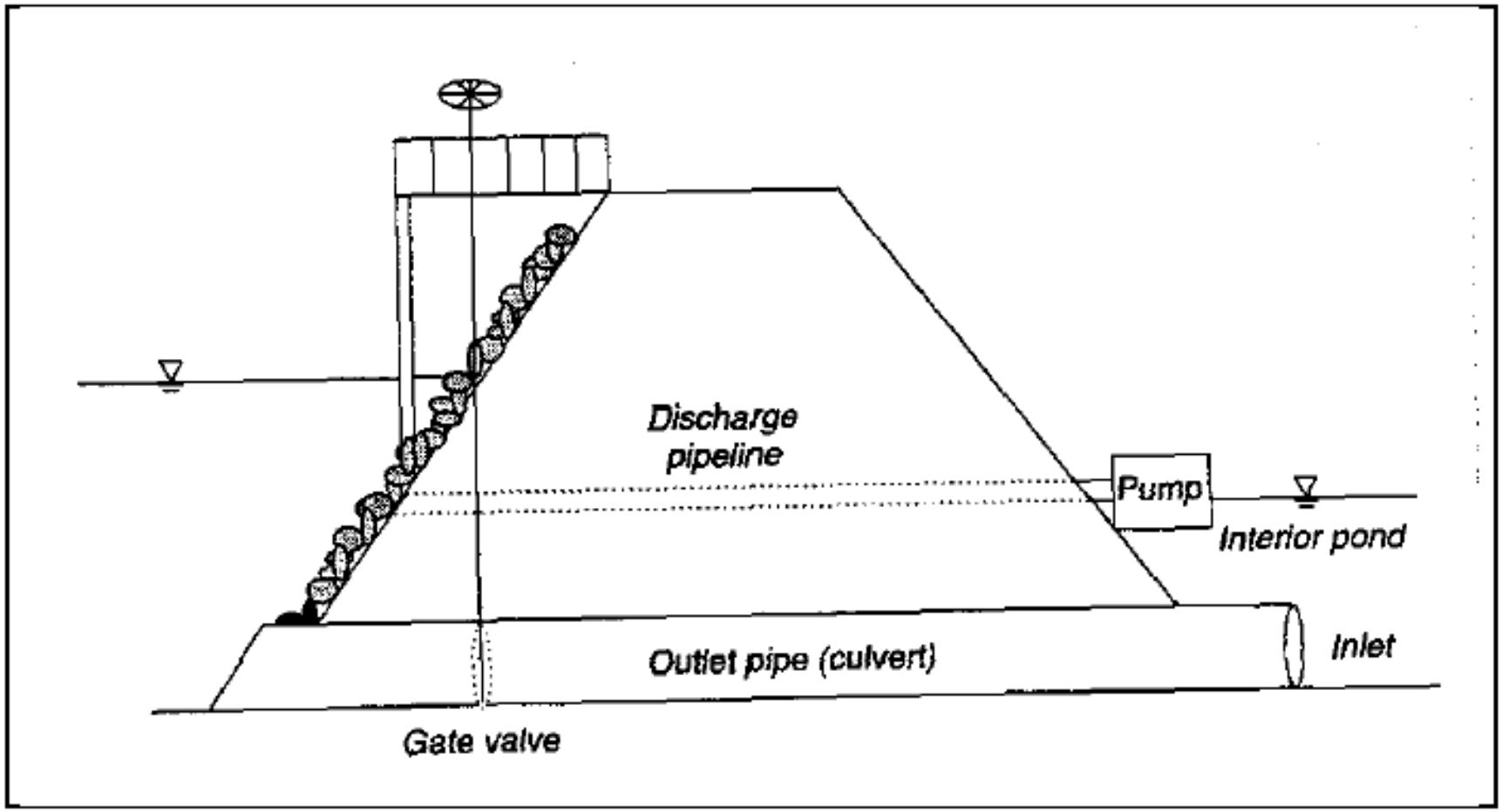


Figure 7-5. Components of interior-area protection system

PUMPS

PUMPS

Non-Structural Measures

- Flood Proofing
- House Raising
- Relocation
- Flood Warning & Evacuation
- Floodplain Regulation

Flood-proofing

- Depth of water in structure up to 2.5 feet
- Uses waterproofing and brick veneer in combination with waterproof closures over doors
- Cost ~$15/sf of structure to be

Structure Raising

- Depth of water in structure from 2.5 feet to 5 feet
- Physically raise houses by use of jacks
- Cost: $50-$100/sf of house (depending on 1 or 2
(200

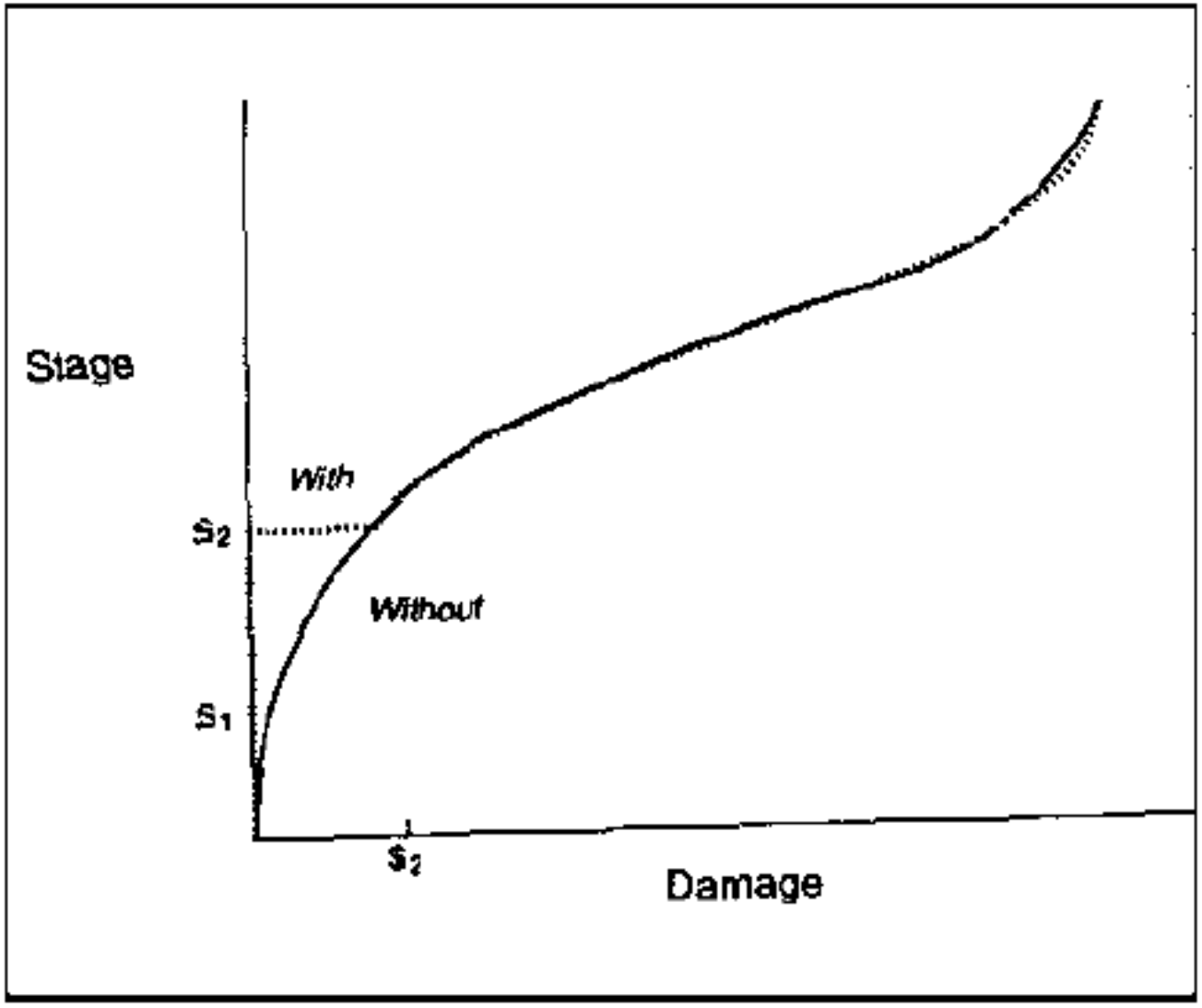


Figure 8-3. Stage-damage function modification due to floodproofing with closure, wall

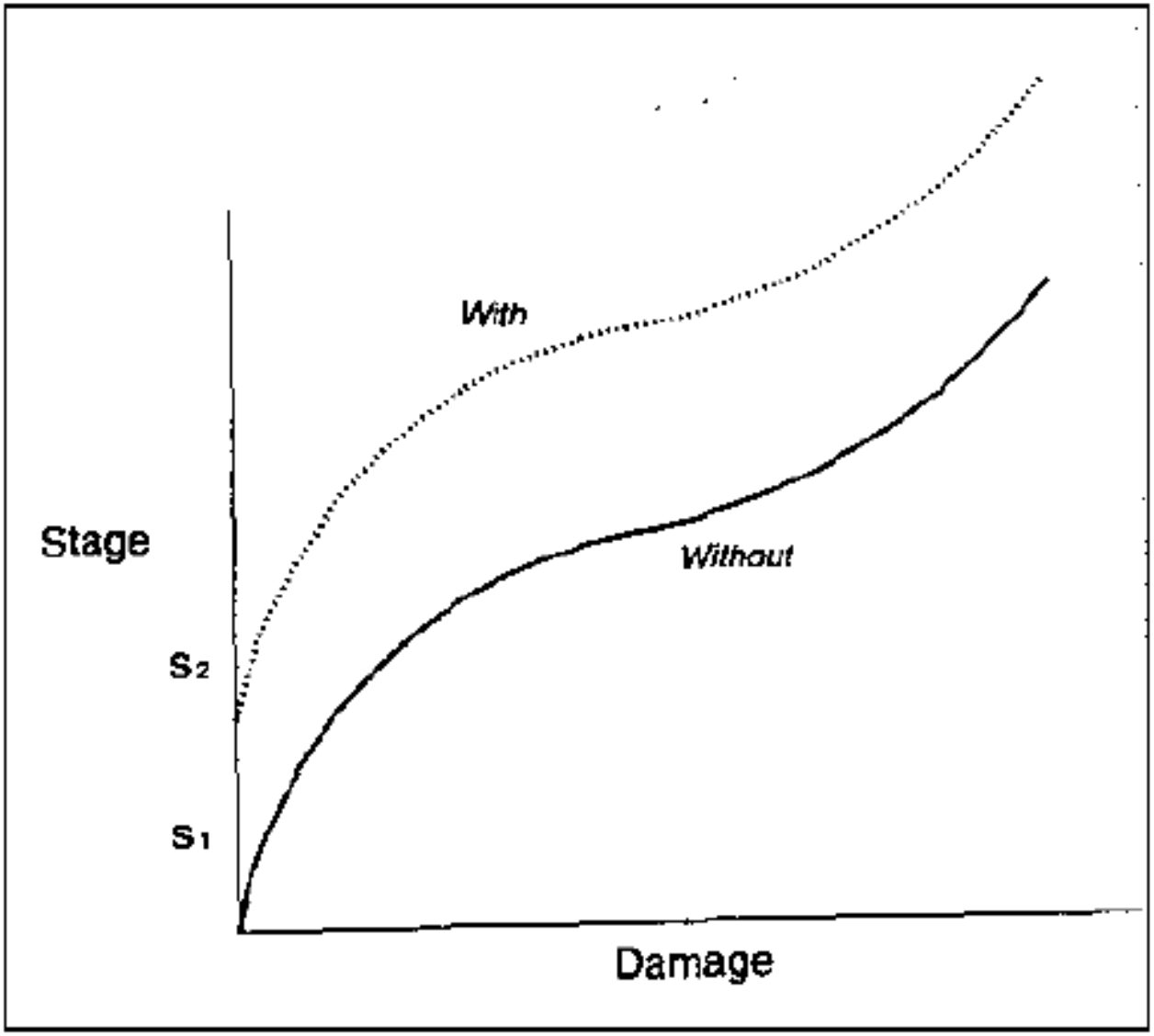


Figure 8-4. Stage-damage function modification due to floodproofing by raising in-place

Relocation

- Moving property so it is less susceptible to damage from flooding. May be accomplished by:
- Relocating Contents within an existing structure at its current location
- Removing the contents or the structure and contents from a flood hazard area

Flood Warning-Preparedness

- May be implemented as:
- A stand alone measure when other measures are not feasible,
- An interim measure until others are in-place,
- A component of other measures

Floodplain Regulation

- Future-condition damage may be reduced through land-use and construction regulation or by acquisition. Although neither is used commonly in Corps flood damage reduction plans, both are potentially components of a complete plan in which costs are shared with local partners.

Floodplain Regulation

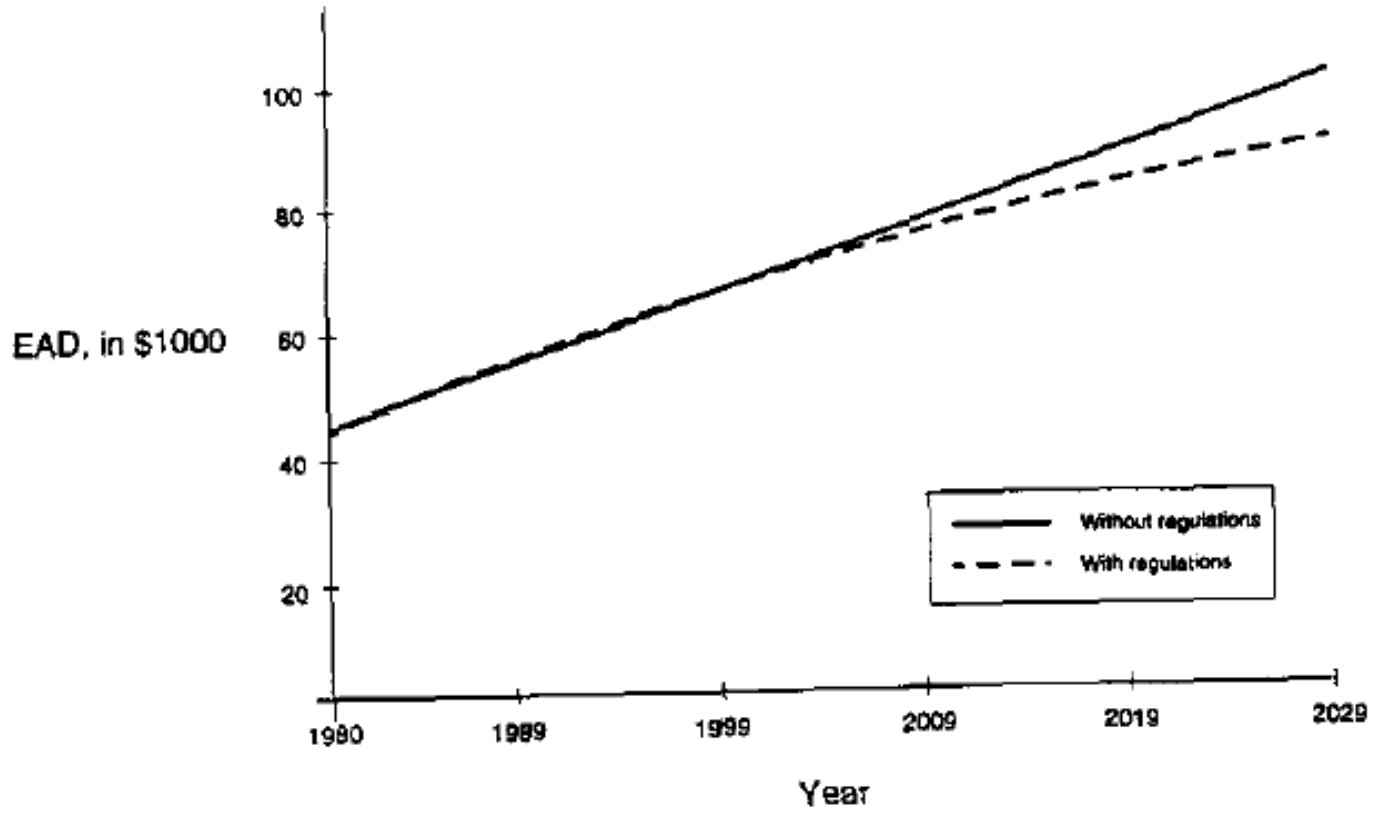


Figure 9-2. Illustration of regulation impact on future-condition EAD

Regional Differences for Flood Damage Reduction Measures

- Ice & Snow
- Arid/Wet Climates
- Soil Infiltrations
- Social Likes/Dislikes

Summary

- **Objectives:** To review for students:
  - An overview of the analyses typically used in Flood Risk Management studies.
  - The type of data needs for H&H analyses.
  - Various types of FRM alternatives (structural and non-structural measures) and the expected impacts of the alternative types.
  - H&H outputs to the study team
- **Questions/Discussion**